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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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R C van Dijk

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(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
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Resource reservation in transmission networks

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DESCRIPTION

Resource reservation in transmission networks

The present invention relates to a transceiver, a radio network, a method for resource reservation and a computer program for a transceiver for resource reservation in a transmission network.

Reliable communication in a network comprising a plurality of transceivers requires methods for the co-existence between the transceivers. For example, a reliable radio- communication over radio-networks requires methods for co-existence between different radio networks or between radio networks of the same type, in case they operate in the same frequency band. This holds especially true in situations where radio resource reservation schemes are to be deployed for the purpose of Quality-of-Service (QoS) management. Most available co-existence schemes rely on some, at least rudimentary means of signalling between the different radio networks.

Radio networks of the standards and types, for example, W-CHAMB, ETSI BRAN Hiper-LAN/2, HomeRF, DECT, Bluetooth/IEEE 802.15 and IEEE 802.11 are developed for the operation in unlicensed bands. In general, those radio networks share radio resources. This is the main reason for their often problematic support of QoS. In case a radio network is co-located with an IEEE 802.11 network, it may occur that the transmission of this radio network suffers from the unpredictable channel access of the stations belonging to the IEEE 802.11 network.

The basic IEEE 802.11 Medium Access Control (MAC) protocol that is common to all types of IEEE 802.11 radio networks is the Distributed Coordination Function (DCF) that works as a listen-before-talk scheme, based on the Carrier Sense Multiple Access (CSMA). Stations transmit data frames after detecting that there is no other transmission in progress on the radio channel. If a co-located network of any other type than IEEE 802.11 leaves the radio channel idle according to its own access protocol for a short period of time, the IEEE 802.11 station might initiate a frame transmission, which then may destroy scheduled frame transmissions in the co-located radio networks in consideration.

It is an object of the present invention to provide for an improved data transmission in transmission networks of a first type which are co-located to a transmission network of a second type.

This object may be achieved with a transceiver according to an exemplary embodiment of the present invention, which is a transceiver of a first type comprising means for transmitting a frame with at least one of a header, a preamble and a payload of a second type for transmission resource reservation.

An advantage of the transceiver according to claim 1 of the present invention appears, in particular, when the transceiver is co-located with a IEEE 802.11 station. Upon reception of this frame, sent by the transceiver according to the above exemplary embodiment of the present invention, the co-located IEEE 802.11 stations will defer from transmission.

A further exemplary embodiment of the present invention is set forth in claim 2. The exemplary embodiment of the present invention as set forth in claim 2 may advantageously allow the transceiver to effectively reserve radio resources. Such a radio resource reservation may increase the data transmission rate of the transceiver of the first type and minimize the amount of unsuccessfully transmitted data frames.

According to the exemplary embodiment of the present invention as set forth in claim 3, the Physical Layer (PHY) header of the transmitted frame comprises an error. Upon receipt of this erroneous PHY header by the co-located network, this co-located network assumes a transmission error due to, for example, errors in the transmission path or a hidden station and defers from transmission for a set period of time. For example, with IEEE 802.11 stations, there is a single parity bit as part of the PHY header (called SIGNAL field). If an error is detected in the PHY header received by this station, an error signal is issued from the PHY layer to the MAC layer at the receiving station and the receiving station defers from transmission.

According to an other exemplary embodiment of the present invention as set forth in claim

4, the PHY header indicates a modulation scheme, which differs from the modulation scheme used for modulation of the payload of the frame. Advantageously, the receiving co-located network is not able to demodulate the payload, assumes an error in the transmission path and may defer from transmission. In particular, in case of a co-located IEEE 802.11 station, the PHY header is correctly decoded (or the PHY header error is not detected). Then, in the PHY layer in the receiving station, an attempt is made to demodulate the payload. Due to the incorrectly indicated modulation scheme of payload in the received PHY header, the payload cannot be demodulated. In this case, an error signal is issued from the PHY layer to the MAC layer, which stops transmission for a set period of time, in case of the IEEE 802.11 station for a time period called Extended Interframe Space (EIFS), which according to IEEE 802.11a is 94 microseconds.

According to yet another exemplary embodiment of the present invention as set forth in claim 5, the transmitted frame comprises an error in the payload of the frame. Upon receipt of this erroneous frame in a co-located network, an error detection mechanism employed in most of the known transmission schemes detects the error in the payload and assumes an error in the transmission path or a hidden station. Thus, it defers from transmission. In particular, in case of a co-located IEEE 802.11 station, upon receipt of the erroneous payload in the frame, there will be an attempt to demodulate the payload of the frame. At the end of the payload, there is a Frame Check Sequence (FCS) based on a Cyclic Redundancy Check (CRC-32). In case the FCS identifies an error, the receiving IEEE 802.11 station will defer for the EIFS time interval after finishing the reception of the signal/frame from transmission.

According to yet another exemplary embodiment of the present invention as set forth in claim 6, the transceiver employs LENGTH/RATE fields in the header of the frame for transmission resource information. Since the transceiver transmits in the modulation scheme of the co-located radio network, the co-located transmission network receives this frame and interprets the included information in the LENGTH/RATE field of the header and will refrain from any transmission during the length of the time period indicated in the LENGTH/RATE field of the header since it assumes that another radio station of this network has priority.

According to exemplary embodiments of the present invention, the above object may also be solved with a radio network as set forth in claim 7, a method for resource reservation in a transmission network as set forth in claim 8, and a computer program as set forth in claim 9.

In case the IEEE 802.11 network is co-located to another network which uses another transmission scheme, it is the gist of the present invention that this other co-located network transmits data frames according to the IEEE 802.11 protocol which cannot be interpreted by the receiving IEEE 802.11 station. When such a data frame is received, the receiving IEEE 802.11 station assumes an erroneous transmission path or a hidden station and defers from any transmission for a time period called Extended Interframe Space (EIFS). Such an erroneous frame may comprise a valid preamble but a PHY header with an error, a valid preamble and a valid PHY header which indicates a different modulation scheme as the modulation scheme used for modulating the payload in this frame, or a valid preamble, a valid PHY header but an error in the payload. In addition to that, these co-located transmission stations may use a LENGTH/RATE field in the PHY header to make the receiving IEEE 802.11 station believe that there is another IEEE 802.11 station with higher priority.

These and other aspects of the present invention will be apparent from and elucidated with reference to the embodiments described hereinafter. Exemplary embodiments of the present invention will be described in the following, with reference to the following drawings:

Fig. 1 shows a time chart for explaining the Carrier Sense Multiple Access /Collision Avoidance (CSMA/CA) algorithm in IEEE 802.11 stations.

Fig. 2 is a sketch for further explaining the "hidden node" problem in IEEE 802.11 stations.

Fig. 3 shows an exemplary embodiment of a transceiver and a radio network according to exemplary embodiments of the present invention.

Fig. 4 shows a flow chart of a method for resource reservation as it may be performed in the

transceiver shown in Fig. 3.

The IEEE 802.11 standard places specifications of the parameters of the Physical (PHY) and Medium Access Control (MAC) layers of a network. The PHY layer, which actually handles the transmission of data between nodes, is specified in the standard or in one of its several extensions.

The MAC layer is a set of protocols which is responsible for maintaining order in the use of a shared medium. The IEEE 802.11 standard specifies a carrier sense multiple access with collision avoidance (CSMA/CA) protocol. In this protocol, when a node receives a packet to be transmitted, it first listens to ensure that no other node is transmitting. If the channel is clear, it then transmits the packet.

This is also referred to a Distributed Coordination Function (DCF). The CSMA/CA requires each station to listen for other users. If a transmission channel such as a radio channel is idle, the station may transmit. However, if it is busy, each station waits until transmission stops, and then enters into a random back-off procedure. This prevents multiple stations from seizing the transmission medium immediately after completion of the preceding transmission. This will be described in the following with further detail, with reference to Figure 1.

Figure 1 shows a time chart for further explaining the CSMA/CA back-off algorithm used in IEEE 802.11. Reference number 1 in Fig. 1 designates a transmission carried out by a source station over the time. Reference number 2 in Fig. 1 designates the transmission of a destination station over the time and reference number 3 designates the behaviour of another station in this IEEE 802.11 network over the time. As may be taken from Fig. 1, after a DIF interframe space (DIFS), which is the necessary space between two transmitted frames, the source stations transmit a data frame. Such a data frame comprises a preamble, a PHY header and payload. The PHY header comprises information which indicates the duration of the frame, the modulation scheme used for the payload of the frame and so on. The preamble, the header and the payload are not shown in Fig. 1. After the source station has sent the data frame, the data frame will be received by the destination station. After the

destination station has successfully received and demodulated the data frame, the destination station returns an Acknowledgement frame (Ack) to the source station. The period between completion of the transmission of the data frame and start of the Ack frame is one Short Interframe Space (SIFS). The Ack frames have a higher priority than other transmissions in the IEEE 802.11 network. Fast acknowledgement is one of the salient features of the IEEE 802.11 standard, because it requires acknowledgement frames to be handled at the MAC layer.

During the frame transmission from the source station to the destination station, the SIFS and the transmission of the acknowledgement frame Ack, other stations are deferred from accessing the transmission medium or channel. Furthermore, the other stations are deferred from accessing the transmission medium or channel for another DCF interframe space (DIFS) after completion of the transmission of the acknowledgement frame Ack from the destination station to the source station.

As part of the collision avoidance mechanism, the station performs a back-off procedure before starting a transmission. This means, when the station listens into the transmission medium or channel and iends the channel as being idle for a certain time period, the DIFS, it still must wait for an additional random time period until the station is allowed to initiate its transmission. The additional random time period is selected from a contention window and is counted in well defined time slots, which divide the contention window in parts of equal lengths. While waiting the random time period to elapse the station decrements its back-off counter each time slot. If the channel is still clear when the back-off counter reaches zero, the station is allowed to transmit. If in the mean time the channel has become busy, the station interrupts the decrementation of the back-off counter during the busy period until the channel is idle for DIFS. Collision detection, for example as the one employed in Ethernet, cannot be used for transmission of IEEE 802.11. The reason for this is that when a station is tramsmitting, it cannot hear any other station in the system which may be transmitting, since its own signal will drown out any others arriving the node.

Whenever a packet is to be transmitted, the transmitting node first sends out a short ready-to-send (RTS) containing information on the length of the packet. If the receiving node

hears the RTS, it responds with a short clear-to-send (CTS) packet. After this exchange, the transmitting node sends its packet. When the packet is received successfully, as determined by the cyclic redundancy check (CRC), the receiving node transmits the acknowledgement Ack frame. This back-and-forth exchange is necessary to avoid the "hidden node" problem, which is illustrated in Figure 2.

Figure 2 shows a schematic diagram for further explaining the "hidden node" problem. In Fig. 2 there is shown a first radio transceiver A 5, a second transceiver B 6, and a third radio transceiver C 7. The coverage regions of the first, second and third transceivers, 5, 6 and 7, are respectively indicated with circles around these transceivers. As may be taken from Fig. 2, radio transceiver A 5 can communicate with radio transceiver B 6 and the radio transceiver B 6 can communicate with radio transceiver C 7. However, the radio transceiver A 5 cannot communicate with radio transceiver C 7. Thus, for instance, although the radio transceiver A 5 may sense the channel to be clear, the radio transceiver C 7 may in fact be transmitting to radio transceiver B 6. The protocol described above alerts radio transceiver A 5 that radio transceiver B 6 is busy, and hence it must wait before transmitting its frames.

A station operating according to IEEE 802.11 that detects a valid preamble, but that is not able to successfully receive the complete frame, assumes a hidden station and is forced to defer from channel access for a long duration, called Extended Interframe Space (EIFS) which is well defined by the IEEE 802.11 standard. As an example, with IEEE 802.11a it is 94 microseconds. There are mainly two different cases of unsuccessful frame reception. The first case is a failure in the PHY layer and the second case is a failure in the MAC layer.

In the following, the case of a failure of the PHY layer will be described in further detail.

After detecting a valid preamble, the PHY layer of the receiving IEEE 802.11 station attempts to decode the PHY layer, which indicates the duration of the frame, the modulation scheme used for the payload of the frame, and so on. Typically, there is an error detection mechanism placed as a part of the PHY header. For example, with IEEE 802.11a PHY, there is a single parity bit as part of the PHY layer, which is called SIGNAL field. If

an error is detected in the PHY header in the PHY layer, an error signal is issued from the PHY layer to the MAC layer at the receiving station. Then, the MAC layer assumes a hidden station and defers from channel access for EIFS.

Another possible situation of a failure in the PHY layer is when the PHY layer is correctly decoded (or the PHY header is not detected). Even in this case, there is a single possibility that the receiving station PHY layer still signals an error signal to the MAC. That happens when the PHY layer is not capable of demodulating the modulation scheme (indicated in the PHY header) used for the payload of the frame.

In the following, the case of a failure in the MAC layer will be described in further detail.

When there is no (detected) error in the PHY header, the PHY of the receiving station will attempt to demodulate the payload of the frame and will deliver the payload to the MAC layer. Usually, at the end of the payload, there is provided a Frame Check Sequence (FCS) based on a Cyclic Redundancy Check (CRC-32). Most of an erroneous frame reception, which happens to pass the PHY header error detection correctly, is usually detected by the FCS check. However, in case an error in the payload is detected by means of the FCS, the MAC layer assumes a hidden station and defers from channel access (an access to the transmission medium) for the EIFS.

Accordingly, it can be said that in case the PHY header and/or the payload comprises an error, the respective IEEE 802.11 station defers from channel access.

Figure 3 shows and exemplary embodiment of a network comprising at least two transceivers 10 and 11, according to the present invention. The transceiver 11 is an IEEE 802.11 station, whereas the transceiver 10 is a transceiver or station employing the W-CHAMB transmission scheme, the ETSI BRAN Hiper-LAN/2 transmission scheme, the HomeRF transmission scheme, the DECT transmission scheme and/or the Bluetooth/IEEE 802.15 transmission scheme or a similar transmission scheme. The transceiver 10 in Fig. 3 further comprises means for transmitting a frame with at least one of the header, a preamble and a payload in the IEEE 802.11 transmission scheme. Simply speaking, when the transceiver 10

carries out a data transmission, it operates in its own transmission scheme. When the transceiver 10 intends to reserve the transmission channel, it operates in the IEEE 802.11 transmission scheme.

When the transceiver 10 operates in the IEEE 802.11 transmission scheme, the means for transmitting the header or the preamble 12 insert an error in the frame transmitted in the IEEE 802.11 format. There are three different options how the means for transmitting the header or the preamble 12 may insert an error in the IEEE 802.11 frame:

First option: The means for transmitting the header or the preamble 12 transmits a valid preamble in the IEEE 802.11 frame with a PHY header with an error. Then, the receiving IEEE 802.11 station attempts to decode the PHY header. Then, the error detection in the PHY layer, usually the single parity bit error detection mechanism in the SIGNAL field, detects the error. If an error is detected in the PHY header in the receiving station, an error signal is issued from the PHY layer to the MAC layer at the receiving station, such that the receiving IEEE 802.11 station will defer for EIFS time interval, after finishing the reception of the signal/frame.

Second option: The means for transmitting the header or the preamble 12 may transmit a valid preamble with a valid PHY header with a valid payload in the IEEE 802.11 frame, with, however, a modulation scheme indicated in the PHY header which does not correspond to the modulation scheme according to which the data in the payload has been modulated. Then, in the receiving IEEE 802.11 station, the PHY header is correctly decoded. However, the PHY layer is not capable of demodulating the payload according to the modulation scheme indicated in the PHY header. Then the PHY layer issues an error signal to the MAC layer, which again assumes a hidden station, and defers from channel access for the EIFS time interval, after finishing the reception of the frame.

Third option: The means for transmitting the header or the preamble 12 transmits a valid preamble and a valid PHY header with a payload. However, the payload comprises and error. If such a frame is received by a IEEE 802.11 station, there is no error detected in the PHY header. The PHY layer demodulates the payload of the frame and delivers the

payload to the MAC layer. The frame check sequence (FCS), based on the cyclic redundancy check (CRC-32) is carried out in the MAC layer, detects the error in the payload and assumes a hidden station. Then, the receiving IEEE 802.11 station defers from channel access for the EIFS time interval.

In addition to that, the means for transmitting the header or the preamble 12 may be adapted to utilize the length and rate information of the PHY header with length and rate information. After reception of such a frame in the IEEE 802.11 station, the station will remain quiet during the period determined by the LENGTH/RATE found in the PHY header, even if there is no signal on the transmission path after the PHY header reception. Thus, by setting the LENGTH/RATE field in the IEEE 802.11 PHY header, the means for transmitting the header or the preamble 12 may defer other stations from accessing the channel for a set period of time and thus successfully reserve the channel or transmission medium.

In other words, if the transceiver 10 uses a different radio transmission scheme and frame format but the same preambles as IEEE 802.11 and PHY headers, the IEEE 802.11 stations will not be able to interpret the data frames following the PHY header. In consequence, the PHY is regularly set to EIFS in all receiving IEEE 802.11 stations, after each detection of a preamble of the other network.

According to the present invention, it is even possible for the transceiver 10 to reserve the medium for an extended period of time by transmitting another preamble in the PHY header during the EIFS duration, which then would set the NAV in the IEEE 802.11 stations again for another EIFS duration. That is, as long as there is no channel idle time gap larger than the EIFS period by transmitting frames with the IEEE 802.11 preamble and the PHY header, the transceiver 10 can continue to occupy the transmission medium or channel without the contention of any IEEE 802.11 stations.

For the sake of efficient spectrum usage, the transceiver 10 may use the preambles not only

for the purpose of radio resource reservation and priority access, but also for synchronization of its own sister stations, i.e. its own network. Alternatively, or in addition, the radio resource reservation by the transceiver 10 may also be preformed by setting the LENGTH/RATE fields in the PHY header such that IEEE 802.11 stations defer from channel access during large time intervals. By transmitting a frame with the IEEE 802.11 preamble and PHY header with the frame LENGTH/RATE to cover the length that is required for priority access.

Figure 4 shows an exemplary embodiment of a method for resource reservation in a transmission network, such as the one shown in Fig. 3, which may be performed in the transceiver 10 of Fig. 3. After the start in step S1, the method continues to step S2, where it is determined whether resource reservation is necessary or not. In case it is determined in step S2 that resource reservation is necessary, the method proceeds to step S3, where the transceiver 10 transmits a frame including at least one of a header, a preamble, and a payload in the IEEE 802.11 format. As indicated above, the frame may include an error, as described in detail with reference to options 1-3, and may also comprise a respective setting in the LENGTH/RATE field of the header. Then, the method proceeds to step S4, where it ends.

In case it is determined in step S2 that no resource reservation is necessary, the method directly proceeds to step S4, where it ends.

The present invention provides for a reliable radio communication over, for example, a radio network, even in case there is a co-existence between different radio networks operating in the same frequency band. Advantageously, according to the present invention, a very efficient Quality-of-Service (QoS) management can be performed.

CLAIMS

1. Transceiver of a first type comprising means for transmitting a frame with at least one of a header, a preamble and a payload of a second type for reservation of a resource for transmission.

2. Transceiver according to claim 1, wherein the first type is selected from the group consisting of W-CHAMB, ETSI BRAN HiperLAN/2, HomeRF, DECT and Bluetooth/IEEE 802.15 and the second type is IEEE 802.11.

3. Transceiver according to claim 1, wherein the means for transmitting the header or the preamble are adapted to transmit the frame with the preamble and the header of the second type such that there is an error in the header of the second type provoking a reception error in another transceiver of the second type which receives the header with the error.

4. Transceiver according to claim 1, wherein the means for transmitting the header or the preamble are adapted to transmit the frame with the preamble and the header of the second type such that a first modulation or coding scheme indicated in the header does not correspond to a second modulation or coding scheme used for the modulation of a payload of the frame provoking a reception error in another transceiver of the second type which receives the frame.

5. Transceiver according to claim 1, wherein the means for transmitting the header or the preamble are adapted to transmit the frame with the preamble and the header of the second type such that there is an error in a payload of the frame provoking a reception error in another transceiver of the second type which receives the frame.

6. Transceiver according to claim 1, wherein the means for transmitting the header or the preamble are adapted to transmit the frame with the preamble and the header of the second type such that length/rate fields in the header are adjusted for reservation of a resource for transmission such that another transceiver of the second type which receives the frame defers from transmission for a time indicated in the length/rate fields in the header.

7. Radio network comprising a transceiver of a first type comprising means for transmitting a frame with at least one of a header, a preamble and a payload of a second type for reservation of a resource for transmission.

8. Method for resource reservation in a transmission network, the transmission network comprising a first transceiver adapted for data transmission in a first transmission protocol and a second transceiver adapted for data transmission and reception in a second transmission protocol, the second transmission protocol being a transmission protocol in which frames are used with at least one of a preamble, a header and a payload, the method comprising the steps of

transmitting a frame with at least one of the preamble, the header and the payload in the second transmission protocol with the first transceiver.

9. Computer program for a first transceiver for resource reservation in a transmission network, the first transceiver being a transceiver in accordance with claim 1, the transmission network comprising the first transceiver adapted for data transmission in a first transmission protocol and a second transceiver adapted for data transmission and reception in a second transmission protocol, the second transmission protocol being a transmission protocol in which frames are used with at least one of a preamble, a header and a payload, the computer program comprising instruction such that when being executed by the first transceiver, the first transceiver performs the following step:

transmitting a frame with at least one of the preamble, the header and the payload in the second transmission protocol.

ABSTRACT

The present invention provides for a reliable communication over radio networks co-existing in the same frequency band. According to the present invention, a transceiver operating according to another transmission scheme may transmit a frame in the IEEE 802.11 format. This frame may comprise an error. Upon receipt of this frame by an IEEE 802.11 station, this station may defer from channel access for a period of time.

(Fig. 3)

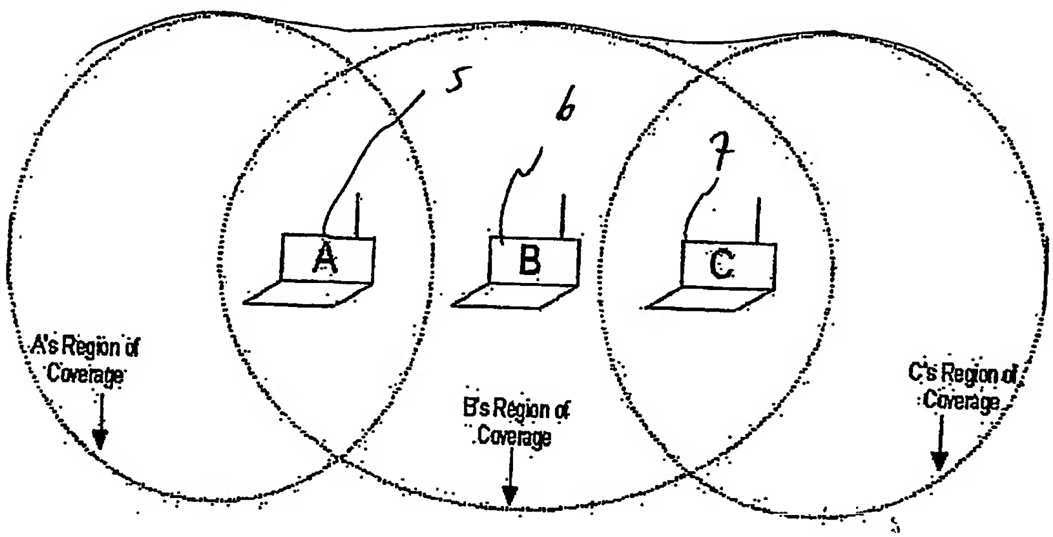
5
6
7
A
B
C
A's Region of Coverage
B's Region of Coverage
C's Region of Coverage

Fig. 2

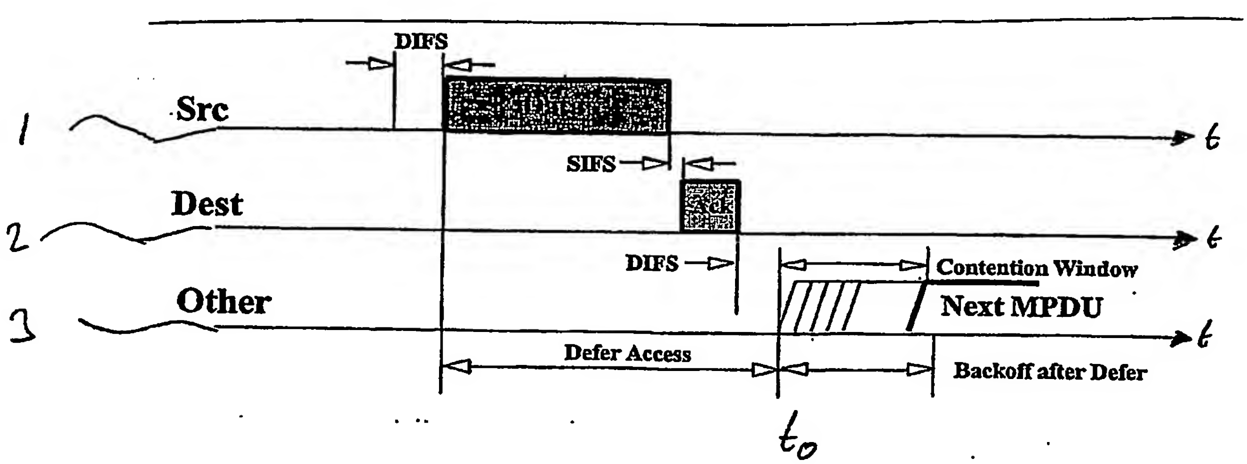
DIFS
Src
1
t
SIFS
Dest
2
t
DIFS
Contention Window
Other
Next MPDU
3
t
Defer Access
Backoff after Defer
t_0

Fig. 1

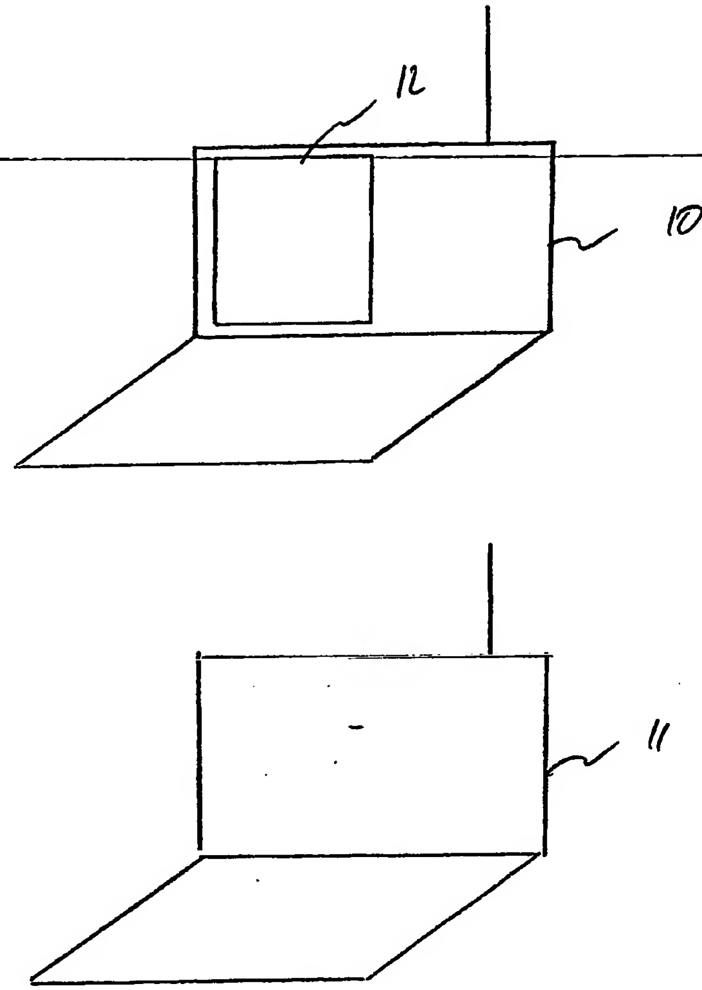

Fig. 3

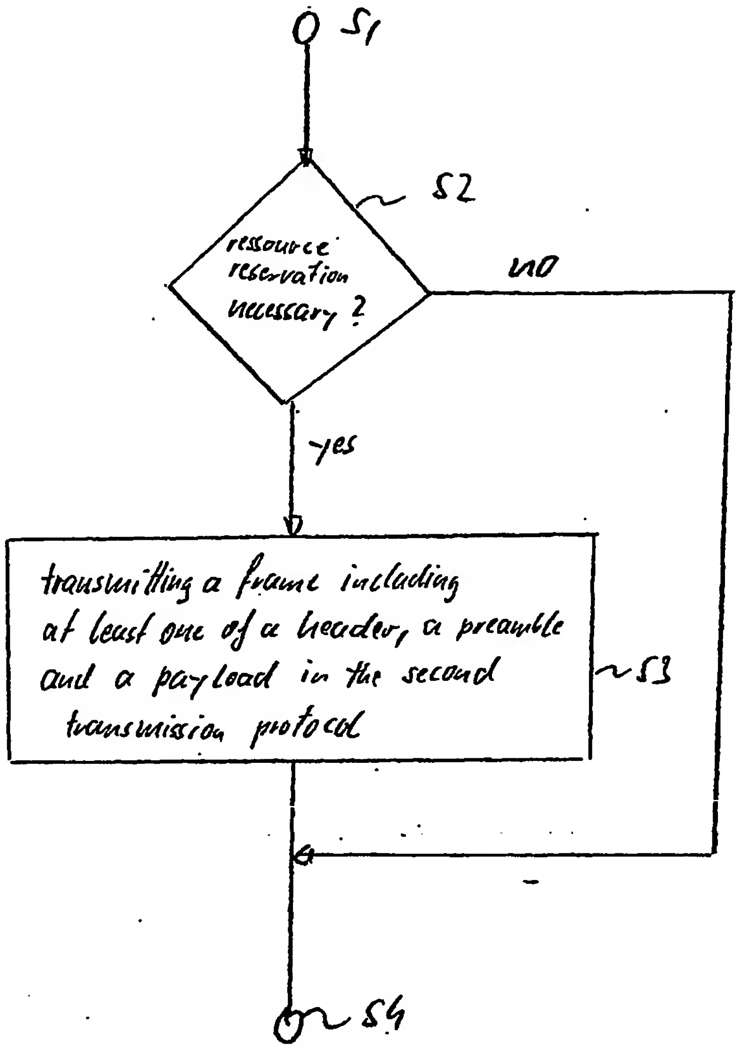
S1
S2
ressource reservation necessary ?
no
yes
transmitting a frame including at least one of a header, a preamble and a payload in the second transmission protocol
S3
S4

Fig. 4